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# PRESSURE REGULATOR MODULE FOR A MOTOR VEHICLE PNEUMATIC BRAKING SYSTEM

Specification

State of the Art

The invention relates to a pressure regulator module for a motor vehicle pneumatic braking system, particularly of a utility vehicle, for the wheel-slip-dependent controlling or regulating of braking pressures applied to two separate working connections, and comprising a two-way valve assembly having one relay valve for each conduit, one solenoid control valve respectively being assigned to the control inputs of each of the two relay valves, according to the preamble of Claim 1.

Such pressure regulator modules are used for controlling and regulating the braking pressure at the vehicle wheels in order to prevent a locking during a braking (antilock system, ABS) or a wheel slip during an accelerating operation (wheel slip control system, ASR). Known antilock systems consist of wheel speed sensors, an electronic controlling and regulating unit as well as the pressure regulator modules. In this case, each individually regulated wheel requires a wheel speed sensor and a pressure regulator module as well as a connection

to the electronic controlling and regulating unit. The ASR uses the same structural members as the ABS but beyond that has an additional valve for building up braking pressure at a spinning wheel independently of the operation of the brake pedal. The wheel-related wheel speed sensor is arranged on the respective vehicle wheel in order to measure the momentary wheel speed and sends a corresponding electrical signal to the controlling and regulating unit which analyzes the signals received from the wheel speed sensors of the additional vehicle wheels as well as other parameters, such as the vehicle speed and the vehicle acceleration and decides whether one or more wheels slip beyond defined values during braking or accelerating. For avoiding an excessive wheel slip, the pressure regulator modules of the controlling and regulating unit are then controlled in order to reduce, increase or maintain the braking pressure in the concerned vehicle wheels. Furthermore, it is known to combine the pressure modulator modules of the wheel of one axle or of one axle side to a single, multi-conduit pressure regulator module in order to save components and installation space.

A 2-conduit pressure regulator module of the above-mentioned type is known from German Patent Document DE 42 27 084 A1, in which case, according to a first embodiment of the citation, a wheel-slip-dependent regulating of the braking pressure is provided in the event that the wheels of one axle

lock during the braking (ABS). The valve unit in each case comprises a solenoid control valve in the form of a 2/2-way valve which is assigned to a relay valve and either blocks the control input of the assigned relay valve or connects it with the output of a bleeder valve connected in front of it, which bleeder valve is connected on the input side with a control pressure and with a bleeding system. Since only one bleeder valve is present, a pressure buildup or pressure reduction, which in each case acts only in the same direction, can take place in the two brake cylinders, while pressure changes in the opposite direction, such as a pressure buildup in one brake cylinder and a pressure reduction in the other brake cylinder, cannot take place. By way of a respective shutting of the 2/2-way valves, however, different braking pressures can be controlled. A total of three solenoid control valves are therefore provided for controlling the two relay valves.

According to another embodiment of the citation, a pressure regulator module is disclosed which, in addition to the ABS during the braking, has an ASR which prevents the slipping of the wheels when starting or accelerating. According to this embodiment, five solenoid control valves are present for controlling the two relay valves.

In contrast, it is an object of the present invention to further develop a pressure regulator module of the initially

mentioned type such that it can be produced in a simpler and more cost-effective manner.

According to the invention, this object is achieved by means of the characterizing features of Claim 1.

Advantages of the Invention

According to a first alternative of the invention, the two solenoid control valves are constructed as 3/2 valves which, without the insertion of additional valves, connect the control input of the respective relay valve with a bleeding system or with a control pressure. As a result of the corresponding controlling of the two solenoid control valves, the braking pressure at the working connections can be individually reduced, maintained or increased in the sense of the ABS. Since only two solenoid control valves are provided for this purpose according to the invention instead of three solenoid control valves as in the prior art, the pressure regulator module can be produced in a smaller size and in an easier and more cost-effective manner.

According to another alternative of the invention, the two solenoid control valves are constructed as 3/2-way valves and, together with only a single additional solenoid control valve, connect the control input of the respective relay valve with the bleeding system, with a control pressure or with a

compressed-air reservoir. In this case, an ASR is also conceivable in addition to the ABS. It is decisive that all functions are implemented by only three instead of five solenoid control valves as in the prior art. This alternative therefore also has the above-mentioned advantages with respect to the saving of installation space, weight and cost. In addition, by means of this valve arrangement according to the invention, an expanded ABS can also be implemented, in the case of which the vehicle stability is increased also without the presence of a braking initiated by the driver by the wheel-individual automatic controlling-in of braking pressure in order to, for example, during a cornering, prevent by means of a targeted braking, a lateral rolling-over of the vehicle. Furthermore, the wiring expenditures are lower in both cases. Also, fewer drivers or interfaces are necessary because of the lower number of solenoid control valves.

As a result of the measures indicated in the subclaims, advantageous further developments and an improvement of the invention indicated in Claim 1 can be achieved.

According to a preferred embodiment of the invention, the two 3/2-way valves are controlled independently of one another by an electronic controlling and regulating unit and, on the input side, are connected with the control pressure and, on the output side are connected in each case with the control

input of the assigned relay valve and with the bleeding system.

In a preferred further development, in the non-energized spring-loaded normal position, the two 3/2-way valves switch the control pressure through to the control inputs of the relay valves and, in the energized position, switch the control inputs of the relay valves through to the bleeding system.

In a particularly preferable manner, for keeping the pressure at the working connection of the respective conduit, the assigned solenoid control valve is alternately switched back and forth into the pressure buildup and pressure reduction position by means of the controlling and regulating unit. As a result of the briefly alternating pressure buildup or pressure reduction, a quasi-constant pressure is reached in a brake cylinder connected with the corresponding working connection without requiring additional measures or components for this purpose.

According to particularly preferable measures, the additional solenoid control valve is formed by another 3/2-way valve which is controlled by the electronic controlling and regulating unit and which is connected on the input side with the control pressure and on the output side with the inputs of

the two solenoid control valves and with the compressed-air reservoir. In the non-energized spring-loaded normal position, the additional solenoid control valve can then switch the control pressure through to the inputs of the two solenoid control valves and, in the energized position, can switch the inputs of the two solenoid control valves through to the compressed-air reservoir.

In particular, the additional solenoid control valve is operated independently of the control pressure and as a function of a wheel slip occurring during the acceleration by means of the regulating and controlling unit. Independently of an operation of the service brake valve, the brake cylinders can therefore be acted upon by pressure from the compressed-air reservoir in order to avoid a spinning during an accelerating operation, whereby the automatic wheel slip control is implemented.

The additional solenoid control valve is preferably integrated in a housing accommodating the valve unit. Furthermore, the additional solenoid control valve may be arranged outside the housing accommodating the remaining valve unit consisting of the two relay valves and the assigned solenoid control valves and can be constructed to be connectable thereto. In this case, it is conceivable to retrofit a pressure regulator module according to the first

alternative of the invention comprising only the antilock function in a simple and rapid manner such that it additionally comprises an automatic slip control. This results in a cost-effective modular design since, based on a basic module consisting of two relay valves and two solenoid control valves, pneumatic braking systems with an ABS function as well as those with an ABS and an ASR function can be implemented.

The center axes of the two relay valves of the valve unit are preferably arranged coaxially and horizontally. This permits a very compact type of construction with only a single central bleeding connection.

Drawings

Embodiments of the invention are illustrated in the drawing and will be explained in detail in the following description.

Figure 1 is a schematic representation of a 2-conduit pressure regulator module of the invention according to a preferred embodiment;

Figure 2 is a braking pressure - time diagram for illustrating an antilock braking system having the pressure regulator module of Figure 1;

Figure 3 is a schematic representation of a 2-conduit pressure regulator module of the invention according to another embodiment;

Figure 4 is a diagram for illustrating a wheel slip control system having the pressure regulator module of Figure 3;

Figure 5 is a schematic representation of a 2-conduit pressure regulator module of the invention according to another embodiment.

Description of the Embodiments

In Figure 1, reference number 1 indicates a preferred embodiment of a pressure regulator module which, according to the invention, is constructed as a 2-conduit pressure regulator module and comprises a valve unit 2 as well as an electronic unit 4 directly connected therewith mechanically and electrically. According to the preferred embodiment, the pressure regulator module 1 is integrated in a pneumatic braking system of a utility vehicle.

The valve unit 2 has two separate pressure regulator

conduits A and B which each comprise a separate relay valve 6, 8 and a solenoid control valve 10, 12 assigned to the latter. The pneumatic control input 14 of the relay valve 6 of conduit A is monitored by the assigned solenoid control valve 10 constructed as a 3/2-way valve. The pneumatic control input 16 of the relay valve 8 of conduit B is monitored by another solenoid control valve 12 also constructed as a 3/2-way valve. The two solenoid control valves 10, 12 have identical constructions and wirings.

Each of the relay valves 6, 8 has several connections of which one connection 18, 20 respectively is connected with a compressed-air reservoir 22 and another output 24, 26 is connected with a bleeding system 28. Furthermore, each relay valve 6, 8 has a working connection 30, 32 which is connected by way of one brake line 34, 36 respectively with a brake cylinder 38, 40 in each case assigned to a vehicle wheel. The two brake cylinders 38, 40 are preferably situated on an axle, such as a front, rear or trailer axle. Parallel to the working connection 30, 32, additional working connections may be present, so that also brake cylinders of two separate axles can be regulated jointly for each side.

Of the three pneumatic connections respectively of the two solenoid control valves 10, 12, one connection 42, 44 respectively is connected by way of a compressed-air pipe 46,

48 with the control input 14, 16 of the assigned relay valve 6, 8. Another connection 50, 52 respectively of the two solenoid control valves 10, 12 is connected by way of a compressed-air pipe 54 with a service brake valve 56 which, as a function of its operation by the driver, outputs a corresponding control pressure into the compressed-air pipe 54. For this purpose, the service brake valve 56 is supplied by way of another compressed-air pipe 58 with stored pressure from the compressed-air reservoir 22. Finally, a third connection 60, 62 respectively of the solenoid control valves 10, 12 is connected by way of a bleeding pipe 66 to the bleeding system 28.

When the pressure regulator module 1 is used in a trailer vehicle, the control pressure in the compressed-air pipe 54 is caused by way of a compressed-air connection, which can be coupled, from the towing vehicle to the trailer vehicle. From there, the control pressure is, in turn, in a direct or indirect operative connection with the service brake valve 56 actuated by the driver. Correspondingly, the compressed-air reservoir 22 to connections 18, 20, when used in the trailer vehicle, is also the compressed-air reservoir of the trailer vehicle.

According to a spring-actuated and currentless pressure buildup position of the solenoid control valves 10, 12

illustrated in Figure 1, the latter switch through the control pressure generated directly or indirectly by the service brake valve 56 and present in the compressed-air pipe 54 to the respective control inputs 14, 16 of the assigned relay valves 6,8, while, in the energized pressure reduction position, they connect the respective control input 14, 16 of the relay valve 6, 8 with the bleeding pipe 66 leading to the bleeding system 28. Therefore, without the insertion of additional valves, the two solenoid control valves 10, 12 can connect the control input 14, 16 of the respective relay valve 6, 8 either with the bleeding system 28 or with the control pressure 54.

The solenoid control valves 10, 12 are controlled by means of one electric line 68, 70 respectively by an electronic controlling and regulating unit 72. The latter comprises at least one microcomputer, which has a separate intelligence, as well as additional electronic or electric components which are not described here in detail and which are capable of processing arriving analog and digital signals.

For this purpose, the electronic controlling and regulating unit 72 has connections 74 for emitting and receiving analog and/or digital signals and connections 74 corresponding to the number of sensed vehicle wheels for sensor input signals reflecting the rotational wheel behavior. The two solenoid control valves 10, 12 can be controlled

independently of one another by the electronic controlling and regulating unit 72, particularly also for raising the pressure in conduit A while simultaneously lowering the pressure in conduit B or vice-versa. As illustrated in Figure 1, in addition, the center axes of the two relay valves 6, 8 are arranged coaxially and horizontally.

Based on this background, the following method of operation of the pressure regulator module 1 illustrated in Figure 1 is obtained:

During a normal service braking, the two solenoid control valves 10, 12 are in the spring-actuated currentless pressure buildup position illustrated in Figure 1, and the control pressure generated by the service brake valve 56 is switched unhindered by the solenoid control valves 10, 12 through to the control inputs 14, 16 of the two relay valves 6, 8. Proportional to this control pressure, the two relay valves 6, 8 introduce a larger volume of braking pressure from the compressed-air reservoir 22 into the brake cylinders 38, 40. The pressure buildup in the brake cylinders 38, 40 also takes place proportionally to the falling control pressure which is present at the control inputs 14, 16 of the relay valves 6, 8 and controls these such that the braking pressure is reduced directly by way of the output 24, 26 of the respective relay valve 6, 8 connected with the bleeding system 28.

During an ABS-regulated braking, during which the controlling and regulating unit 72 recognizes overbraked wheels with an increased wheel slip, the two conduits A, B containing one solenoid control valve 10, 12 and an assigned relay valve 8, 10 respectively are controlled separately from one another, and thus the supply of control pressure from the service brake valve 56 to the two relay valves 6, 8 is regulated individually. By means of the pressure regulator module 1 according to the invention, conditions are, for example, conceivable here in which the control pressure of one relay valve 8 is raised and simultaneously the control pressure of the other relay valve 6 is lowered and also different pressure levels are regulated. This is so, for example, when one wheel of the axle is, for example, on ice and the other wheel is on a dry nonskid base.

Figure 2 shows, for example, the braking pressures $p_A$, $p_B$, which are entered over the time, in the two conduits A, B or brake cylinders 38, 40 of the axle or axles in the case of a joint pressure regulating during a braking with an ABS function. The number 1, which is entered on the bar situated underneath, means that the solenoid control valve 10, 12 assigned to the respective conduit A, B or brake cylinder 38, 40 is energized, and the number 0 means that the corresponding solenoid control valve 10, 12 is non-energized.

As illustrated in Figure 2, during an initial braking phase I, first the pressure in the two conduits A, B is increased in a uniform manner in that the two solenoid control valves 10, 12 at first remain non-energized, and the control pressure generated by the service brake valve 56 reaches the control inputs 14, 16 of the two relay valves 6, 8 unhindered in order to control proportional and at first equally large braking pressures $p_A$, $p_B$ into the two brake cylinders 38, 40. When the wheel slip exceeds unacceptable values on the wheel assigned to the conduit A, the braking pressure is first reduced during a phase II in the corresponding brake cylinder in that the assigned solenoid control valve 10 is energized by the controlling and regulating unit 72 and is therefore switched into the pressure reduction position. During a further phase III, the braking pressure $p_A$ in the conduit A is held at an approximately constant level in that the solenoid control valve 10 assigned to the conduit A is alternatingly switched back and forth between its pressure buildup position and its pressure reduction position. In this case, the switching points are situated at very brief intervals behind one another so that a quasi-static braking pressure $p_A$ which oscillates about a constant value is obtained at the assigned brake cylinder, as illustrated in Figure 2. During phase IV, which follows, the braking pressure $p_A$ in the conduit A is raised in order to achieve a braking effect which is as large

as possible when the wheel slip is optimal. For this purpose, the solenoid control valve 10 is switched into the pressure buildup position.

The controlling of the two conduits A, B or brake cylinders by the controlling and regulating unit 72 takes place individually and separately, so that, for example, a reduction of the braking pressure $p_A$ becomes possible during phase II in conduit A while simultaneously the braking pressure $p_B$ in conduit B is further increased. For this purpose, the two solenoid control valves 10, 12 are switched in opposite directions; that is, the solenoid control valve 10 of conduit A is in the pressure reduction position and simultaneously the solenoid control valve 12 of conduit B is in its pressure buildup position illustrated in Figure 1.

In the second embodiment of the invention according to Figure 3, the parts remaining the same and having the same effect with respect to the preceding example are marked by the same reference numbers. In contrast to the latter, the otherwise unchanged valve unit contains an additional solenoid control valve 76 as the 3/2-way valve, which is connected in front of the two solenoid control valves 10, 12 of conduit A and B and is integrated in a housing 78 accommodating the valve unit 2. The additional solenoid control valve 76 is connected by means of a compressed-air pipe 80 on the input

side with the service brake valve, which is not shown in Figure 3 for reasons of scale, or a compressed-air pipe, which can be coupled, for the control pressure when a trailer is used, and is connected on the output side by way of a compressed-air pipe 82 with one input 50, 52 respectively of a solenoid control valve 10, 12 as well as, by means of another compressed-air pipe 84, with the compressed-air reservoir 22, and is controlled by way of an electric line 86 by the controlling and regulating unit 72. In the non-energized spring-loaded normal position according to Figure 3, the additional solenoid control valve 76 switches the control pressure present in the pipe 80 through to the connections 50, 52 of the two solenoid control valves 10, 12, while, in the energized condition, it connects these connections 50, 52 with the compressed-air reservoir 22. The two solenoid control valves 10, 12 assigned to the relay valves 6, 8 can therefore, together with the only one additional solenoid control valve 76, connect the control input 14, 16 of the respective relay valve 6, 8 with the bleeding system 28, with the control pressure 80 or with the compressed-air reservoir 22. Independently of the control pressure 80 and as a function of a wheel slip occurring, for example, during an acceleration, the additional solenoid control valve 76 is actuated by the controlling and regulating unit 72 and is preferably integrated in the valve unit 2.

In the form of a diagram, Figure 4 illustrates the course of the brake pressure $p_B$ and the rotational speed $v_B$ of a driven wheel which, during the acceleration, is initially spinning and is braked by the ASR function integrated in the pressure regulator module 1 according to Figure 3, to which wheel, for example, conduit B of the pressure regulator module 1 is assigned, in comparison to the brake pressure $p_A$ and the rotational speed $v_A$ of a wheel which is also driven but does not slip in an unacceptable manner and is assigned to conduit A. The controlling and regulating unit 72 detects the spinning wheel by a comparison of the speeds $v_A$ and $v_B$. If, as in the present case, the wheel assigned to conduit B has a higher speed than the wheel of conduit A, the controlling and regulating unit 72 controls the valve unit 2 in order to control brake pressure into the brake cylinder 40 of the spinning wheel for transmitting driving torque onto the wheel with the better traction by braking the spinning wheel.

Specifically, for this purpose, the additional solenoid control valve 76 and the solenoid control valve 10 assigned to the non-slipping wheel of conduit A are energized, as illustrated particularly in the center bar diagram of Figure 4, in which an energizing is marked with the number "1" and the currentless condition is marked by the number "0". As a result, compressed air from the compressed-air reservoir 22 arrives in the brake cylinder 40 of the spinning wheel for

braking it. The braking pressure $p_B$ controlled into the brake cylinder 40 of the spinning wheel of conduit B is then regulated as a function of the slip rate of the spinning wheel and of the change of speed of this wheel, in that the solenoid control valve 12 assigned to the spinning wheel is alternatingly switched back and forth between the pressure buildup position and the pressure reduction position, as illustrated particularly in the lower bar diagram of Figure 4. As a result, the wheel speed $v_B$ of the spinning wheel approaches the speed $v_A$ of the non-spinning driving wheel.

In the embodiment of Figure 5, the additional solenoid control valve 76 is not integrated according to Figure 3 into the housing 78 accommodating the valve unit 2, but is arranged outside of this housing 78. More precisely, the additional solenoid control valve 76 is arranged outside the housing 78 accommodating the remaining valve unit 2 consisting of the two relay valves 6, 8 and the assigned solenoid control valves 10, 12, and is constructed to be connectable to the valve unit 2. It is shown that the remaining valve unit 2 accommodated in the housing 78 corresponds to that of the embodiment of Figure 1. For this purpose, the additional solenoid control valve 76 is only connected between the service brake valve 56 and the two solenoid control valves 10, 12 and is connected by way of an electric line 86 to the controlling and regulating unit 72 and by means of a compressed-air pipe 84 to the compressed air

reservoir 22. Then, as a result of the connection of the additional solenoid control valve 76 to the pressure regulator module 1 according to Figure 1, the already existing ABS functionality can be supplemented by ASR functions.

However, the embodiments according to Figures 3 and 5 can also be used in an electronically monitored rollover protection system. Such as system can be integrated in an ABS system and, in addition to corresponding software, requires in principle only additional information concerning the momentary lateral acceleration and a valve construction according to Figure 3 or Figure 5. By assessing the measured or calculated lateral acceleration for the momentary driving speed, the electronic controlling and regulating unit 72 can detect a possible overturning risk early, for example, during a cornering at an excessive speed. By activating the 3/2 solenoid control valve 76 and the individual controlling of the control valves 10 and 12 connected on the output side, independently of the driver's reaction, as a result of an automatic no-lock braking of the corresponding vehicle, the driving speed can be reduced and a possible overturning risk can thereby be eliminated.

Such a rollover protection system is particularly effective in a trailer vehicle because, first, the turnover risk itself, as a rule, originates from the trailer and,

second, as mentioned above, few additional expenditures are required for an ABS system.

When a lateral acceleration sensor is integrated in the electronic controlling and regulating unit 72 and the valve unit 72 is constructed according to Figure 3 or Figure 5, not only is a very compact unit obtained, but the wiring and mounting expenditures are also minimized.

## List of Reference Numbers

| | |
|---|---|
| 1 | Pressure regulator module |
| 2 | valve unit |
| 4 | electronic unit |
| 6 | relay valve |
| 8 | relay valve |
| 10 | solenoid control valve |
| 12 | solenoid control valve |
| 14 | control input |
| 16 | control input |
| 18 | connection |
| 20 | connection |
| 22 | compressed-air reservoir |
| 24 | output |
| 26 | output |
| 28 | bleeding system |
| 30 | working connection |
| 32 | working connection |
| 34 | brake line |
| 36 | brake line |
| 38 | brake cylinder |
| 40 | brake cylinder |
| 42 | connection |
| 44 | connection |
| 46 | compressed-air pipe |

| | |
|---|---|
| 48 | compressed-air pipe |
| 50 | connection |
| 52 | connection |
| 54 | compressed-air pipe |
| 56 | service brake valve |
| 58 | compressed-air pipe |
| 60 | connection |
| 62 | connection |
| 66 | bleeding pipe |
| 68 | electric line |
| 70 | electric line |
| 72 | controlling and regulating unit |
| 74 | connections |
| 76 | solenoid control valve |
| 78 | housing |
| 80 | compressed-air pipe |
| 82 | compressed-air pipe |
| 84 | compressed-air pipe |
| 86 | electric line |